COLLEMBOLA (Spring-tails)

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Of the three orders of insects—Thysanura (Bristle-tails), Protura (Primitive-tails), and Collembola (Spring-tails)—which are placed in the sub-class Apterygota, the last is, in many respects, the most specialized. Although the others are more generalized in their structure, fossil remains of the first order have not been found earlier than the Amber-beds of Europe and no remains of the second are known, yet undoubted representatives of the Collembola have been found in the Rhynie Chert-beds (Middle Devonian) of Scotland, these thus being the earliest fossil insects known.

In this regard it is interesting to note here that when Dr. R. J. Tillyard correctly placed these fossils as Collembola in 1928 (*Trans. Ent. Soc.*, London, pp. 65-71) he had only four imperfectly preserved heads before him. Since then a few other and more complete specimens have been examined by the writer, while in London in 1930, and Dr. Tillyard's conclusion can not only be confirmed, but from all the minute details visible in these specimens—antennae, mandibles, ocelli (8 on each side), claws and ventral tube (the best specimen is complete from head to the second abdominal segment)—the species, *Rhyniella praecursor*, Hirst and Maulik, can be definitely placed in the family *Hypogastruridae*.

Collembola are primitively wingless insects with not more than six abdominal segments. The head is oval with internal mouth-parts and carries a pair of four-segmented (rarely six-segmented) antennae. The eyes consist of simple ocelli varying from none to eight (Plate XXIX, Fig. 2) on each side. Between the antennae bases and the ocelli is often to be found an organ of uncertain function, the post-antennal organ (Plate XXIX, Fig. 2, 8), which may take the form of a simple ellipse, a number of lobes arranged spherically, or a more complicated structure. The third and fourth antennal segments often carry sensory organs, generally in the shape of small rods or papillae (Plate XXIX, Fig. 9, 15), possibly of an olfactory nature.

The thorax is composed of three segments, but in some of the higher forms the prothorax is not visible from above, and in others the segmentation is very indistinct. The legs are well developed with the tibia and tarsus combined to form a single segment, the tibiotarsus. This segment ends in a single large claw and a small outer claw or *empodium* (Plate XXIX, Fig. 3, 10,

13). Above the claw is sometimes to be found one or more clavate tenent hairs.

The abdomen carries ventrally on the first segment a tube or *collophore* from which can be exserted a pair of long filaments. The collophore is generally spoken of as the ventral tube. From the fourth or fifth segment on the ventral surface arises in typical species the unique *furca* or spring. This organ consists of a basal piece or *manubrium*, followed by a pair of *dentes*, each of which is tipped by a small claw-like piece, the *mucro*. When in repose, the furca is folded beneath the body and held by the catch or *hamula* which is situated on the third segment.

The clothing of these small insects is generally of simple, ciliated, pointed or clavate hairs. Many species, however, may be more or less naked and others are covered with scales of various types. Sexual dimorphism is unusual in the Collembola, but is not unknown. In the males of species belonging to the tribe Sminthuridini of the Symphypleona, the antennae are modified by the addition of curved hooks or spines which serve to hold the female during copulation (Plate XXIX, Fig. 18). In the genus *Bourletiella* similar hooks are present on the anal segments of the male. In the Arthropleona, secondary sexual characters such as spines or modified hairs and scales are to be found on various parts of the body in some species of the genera related to Isotoma. Colour in Collembola is very variable, even within the species, and is only of limited use for systematic purposes.

The life-history of these minute creatures is very simple. The eggs are laid on the ground, under rotten bark or on other pabulum inhabited by the adults. The newly-hatched nymph does not differ morphologically from the adult, but is generally of a lighter colour. The skin is cast some 6-8 times during life. Most species are humus feeders, but many are phytophagous, some, such as *Sminthurus viridis* L. (the Lucerne Flea) (Plate XXVIII, Fig. 3), being ravagers of clover and lucerne. A few species are carnivorous, feeding upon decaying barnacles, molluscs, earthworms and the like. One species, *Hypogastrura viatica* Tlbg., feeds on the algae, etc., growing on the surface of sewage filters, and is thus useful. With only one or two exceptions, respiration is cutaneous, tracheae being entirely wanting. The chief exception is *S. viridis*, which is provided with a complex system of tracheal tubes.

Collembola abound almost everywhere, often in incredible numbers. They are to be found among herbage, on the surface of ponds, on and in manure heaps, on the ground under stones and logs, and in the house. They swarm sometimes on the surface of snow at high altitudes and are found from the sub-polar to the tropic regions. They are essentially insects of the damper

climates, being most abundant in the wet periods of the year. Some species have a very wide distribution throughout the globe, many of them doubtlessly distributed by man, others by more natural means, such as wind and sea currents and on the feet of birds and the like. As an example of the first manner one has only to think of the Lucerne Flea, which was almost certainly brought over here by man. Many other species which are probably natives of Europe and America are now known to occur commonly on cultivated land in Australia, and all these in our more propitious climate should be looked upon as potential pests. A rare species found in two localities in Western Australia, *Folsomina onychiurina* Den. (Plate XXIX, Fig. 14-16) is only known from Costa Rica. *Axelsonia littoralis* Monz. (Plate XXIX, Fig. 11-13) is a shore-inhabiting species found in Western Australia, but also recorded from Japan, America and Europe. This species feeds upon decaying molluscs, etc. Another shore species, *Anurida maritima* Guer., has been found on many coasts in both hemispheres, but not yet in Australia. Here and in New Guinea it is replaced by a closely allied genus, *Pseudanurida* (Plate XXIX, Fig. 5-6). Some of the New Zealand species are also inhabitants of the Sub-antarctic Islands.

Until the last few years, the Collembolan Fauna of Australia was very little known. In 1907 J. W. Rainbow described the first two species, other than *Sminthurus viridis* L., to be recorded, namely, *Xenylla mucronata* Axels. (*Achorutes speciosus* Rainbow) and *Proisotoma minuta* Tullberg (*Isotoma troglodytica* Rainbow), both of which have since been shown to be European species. In 1917 appeared Schött's important paper on the material collected by the Mjöberg Swedish Exped., when he described four species and one variety of the Symphypleona, five species of Arthropleona-Poduroidea and thirty-three species of Arthropleona-Entomobryoidea. In 1932, in a short paper on the Tasmanian species, the writer added six species of Symphypleona, three of which were new. In the same year the writer published, as a Pamphlet of the C.S.I.R., a preliminary account of the Symphypleona of Australia, in which no fewer than 35 species of this sub-order were listed. In this paper, for the first time, representatives of the family Neelidae (Plate XXIX, Fig. 17) were recorded from Australia. In 1933 the super-family Poduroidea of the Arthropleona was dealt with and the number of Australian species raised to thirty, many of them introduced forms and potentially dangerous. In the same year in "Stylops" nine more Symphypleonids were described, making the total for this country forty-six. At the present time the super family Entomobryoidea is being dealt with in a paper in the *Proc. Roy. Soc. S.A.*, in which the number occurring here totals ninety-one.

Another paper in the press also adds several species of the Poduroidea. The total species of Collembola now recorded is 171, but the writer has quite a number of additions still to be described and doubtlessly, when our tropical parts are explored for these minute creatures, the total fauna will approach 3-400 species.

In this paper, only the main outlines of the classification can be given, but entomologists and others interested should refer to the papers by the writer and quoted in the bibliography.

The order falls naturally into two well-defined sub-orders as follows:—

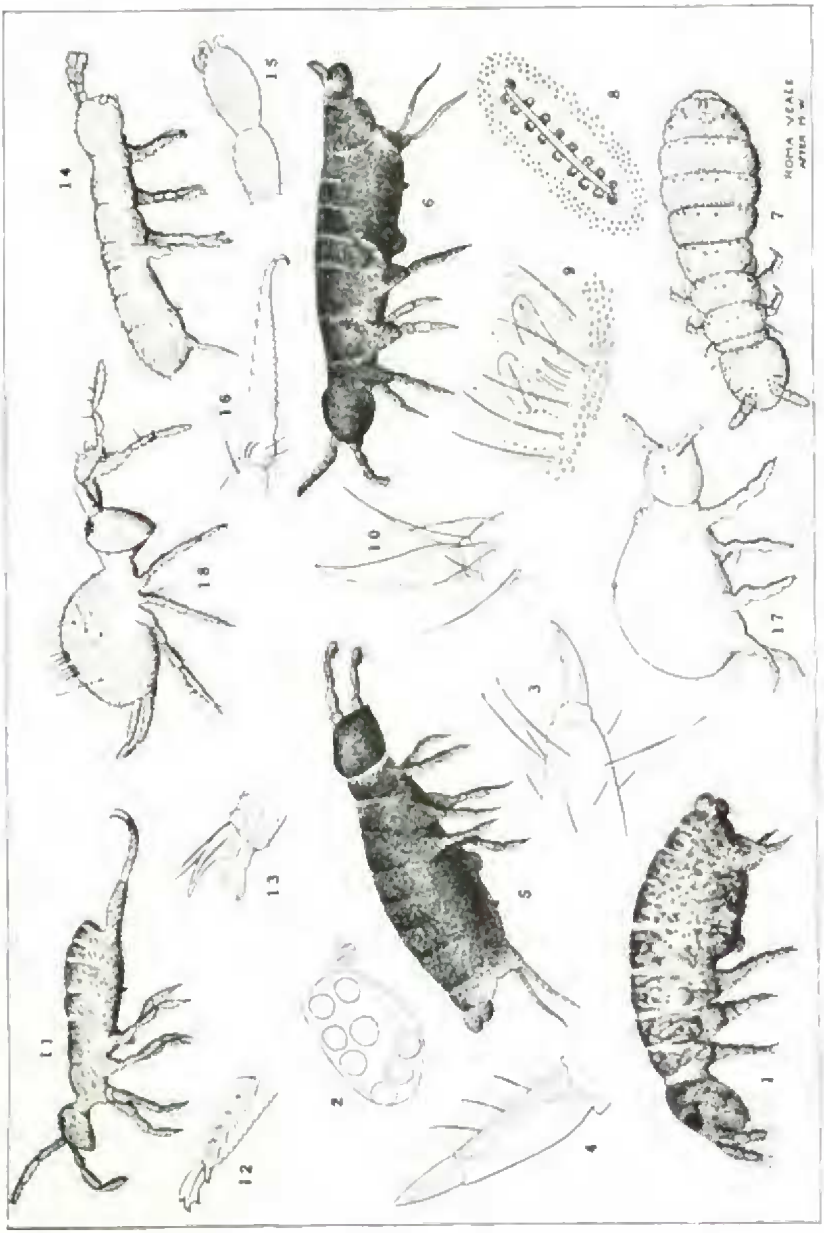
1(a) Insects of elongate form with thorax and abdomen distinctly segmented.
Arthropleona Börner 1901.

(b) Insects of globular form with segmentation indistinct.
Symphypleona Börner 1901.

The Arthropleona are again divided into two super-families, the Poduroidea, in which the prothorax is well developed, with hairs or setae, and visible dorsally; and the Entomobryoidea, in which the prothorax is reduced and not visible from above.

The Poduroidea contains three families, Poduridae, Hypogastruridae and Onychiuridae, of which the first is represented by only a single genus and species and does not occur in Australia. Of the Hypogastruridae, ten genera occur here, all of which, with the exception of *pseudanurida* and *Ceratrimeria*, are well known in Europe and elsewhere. The genus *Hypogastrura* has four species in Australia, all well-known European or even cosmopolitan forms. *Xenylla* is represented by four species, two of which are probably indigenous, the others European. *Brachystomella*, a curious genus lacking mandibles, has seven or eight species, one being European and one known from South Africa. The members of this family are generally rather stout, stumpy species, often lacking the furca, sometimes without eyes, and frequently with two or more anal spines. Most of them are of a dull colour, brown or black. The commonest species, occurring everywhere in garden humus, manure heaps, etc., often in tremendous numbers, is *Hypogastrura armata* (Nic.). It is cosmopolitan in its distribution and is sometimes a source of damage to mushrooms. Another very common species on our cultivated land is *Brachystomella parvula* (Schffr.) (Plate XXIX, Fig. 1-4). This is smaller and bluer than the preceding and lacks the anal spines and also the mandibles. In the sub-family Achorutinae several species of the genus *Achorutes* are indigenous. They are rather characteristic forms with large segmental tubercles on the body, without a furca, with only two or three

Plate XXIX



Spring-tails (Collembola, entire Figures and Structural Details

ocelli on each side and generally blue, white, yellow or pink in colour. Those of a red or yellow colour lose this when preserved in spirit.

The family *Onychiuridae* is represented only by the genera *Onychiurus* (Plate XXIX, Fig. 7-10) and *Tullbergia* in Australia. They are whitish, elongate insects without a furca and with a very complicated postantennal organ, which usually consists of a double line of single tubercles or granular bunches of tubercles lying in a long groove. The sensory organ on the third antennal segment is also very complicated. On the body segments are a number of sensory pits which are termed "pseudocelli." The few species which occur here are mainly, probably, of European origin and because of the numbers in which they occur potential pests. They are soil insects, feeding upon humus and the rootlets of plants.

The super-family Entomobryoidea contains the three families Isotomidae, Tomoceridae and Entomobryidae. The Isotomidae contains many genera and species, all of which are elongate and graceful forms and mostly of a white to blue colour. They are largely humus feeders, although a number of species in Europe have been recorded as damaging plants. Many of our common species are known from Europe and America. Of these *Entomobrya multifasciata* Tullberg and *Entomobrya clitellaria* Guthrie (Plate XXVIII, Fig. 1) are everywhere in our gardens and pastures. The first of these is almost cosmopolitan, the second known only from America. The Tomoceridae are represented in Australia only by two species of the genus *Lepidophorella*, *L. australis* and *L. brachycephala*. These have some spine-like scales on the furca and a falciform mucro. They are very active insects, found plentifully under logs and stones in the bush. The genus Tomocerus is as yet unknown here, but the European *Tomocerus minor* Lubbock occurs in New Zealand. The Entomobryidae contains a large assemblage of both scaled and scaleless forms. In the sub-family Entomobryinae, only the tribe Entomobryini is so far known to occur here. They are elongate insects in which the fourth abdominal segment is very much longer than the third. The body generally is clothed with long hairs which, around the head and neck, are clavate at the apex and ciliated. Many species are to be found under stones, logs, plant-pots and the like, and some are confined largely to the nests of ants and termites. Others may be obtained by sweeping the herbage.

Sinella coeca Schött and *S. termitum* are blind species of a white colour, although often with small pink spots of pigment. The first is a European form, the second indigenous. The species of the genera *Lepidocyrtus*, *Sira*, *Lepidocyrtoides*, and *Lepidosira* and their allies are scaled. In the sub-family Paronellinae, we